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JANUARY, 1931

DEPARTMENT OF COMMERCE

UNITED STATES BUREAU OF MINES
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MINING, TREATMENT METHODS AND COSTS, MENANTICO SAND AND GRAVEL CO., MILLVILLE, N. J.

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MINING, TREATMENT METHODS AND COSTS, MENANTICO SAND AND GRAVEL CO., MILLVILLE, N. J.[1]

By Hugh Haddow, jr.[2]

INTRODUCTION

This paper describing the methods of recovery and treatment of a sand and gravel deposit and the preparation of these materials for a number of special markets is one of a series being prepared by the U. S. Bureau of Mines. It is of particular interest to those sand and gravel operators who have a surplus of fine sand which must be sent to waste, both from the point of view of equipment and the variety of markets supplied, and in that it describes one of the few sand and gravel plants which have resorted to hydraulic classification for sizing fine sand.

ACKNOWLEDGMENTS

The author wishes to acknowledge the assistance of J. R. Thoenen, mining engineer of the Bureau of Mines, in the preparation of this paper.

HISTORY

In the early operation of the deposit sand and gravel for making concrete were the only products. Later on the demand for special sands necessitated separate plant units for their preparation, which was followed by the erection of another separate plant for the utilization of the fine sand wasted from former operations, as markets were developed for this material. The present plant is the result of a gradual development brought about by the necessity of producing various special kinds or gradings of sands and gravels.

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1 The Bureau of Mines will welcome reprinting of this paper, provided the following footnote acknowledgment is used: "Reprinted from U. S. Bureau of Mines Information Circular 6420."

2 One of the consulting engineers of the Bureau of Mines; vice president and general manager, Menantico Sand and Gravel Co.

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Previous to the formation of the present company the deposit had been worked in a small way for the production of concrete gravel and blast sand. In the spring of 1914 the present company took over the property and constructed an entirely new plant. At that time the only outlet for material was a small market for concrete gravel in Atlantic City and a fair market for blast sand in New Jersey and Eastern Pennsylvania. Several sand plants were already in operation in this section but they were almost entirely occupied in supplying sand to glass factories, foundries, and for water filtration.

The property consists of about 300 acres with a small stream, Menantico Creek, running through it close to the western boundary. The Pennsylvania Railroad tracks traverse the property on the southern edge so that excellent transportation is afforded.

DESCRIPTION OF DEPOSITS

The deposits at Millville are all of fine sand and gravel that offer no serious difficulty to the operation of a pump dredge. On the property are two classes of deposits which are called Highland and Lowland. The Highland deposit extends from 10 to 20 feet above water to an average of 20 feet below water level. This deposit has no overburden and supports a weak growth of scrub oak and pine. The Lowland deposit is adjacent to the stream and extends from 2 to 5 feet above water to an average depth of 22 feet below water level. The overburden on this deposit is decayed vegetable matter mixed with sand and forms a black mat from 6 inches to 3 feet in thickness over the deposit.

PHYSICAL CHARACTERISTICS

Gravel deposits in all of Southern New Jersey are of small area and adjacent to small streams. The gravel itself is unusually small with almost none over 2 inches in size. On the other hand, sand of almost every size is found in abundance.

The Lowland deposit is comparatively shallow, but consists largely of gravel and coarse sand, and was the first deposit worked because it contained from 20 to 25 per cent of gravel and about 35 per cent of coarse sand which were the only products of value during the early operation of the deposit. The balance of fine sand was then considered as waste.

Chemically, the material shows an analysis of from 96 to 98 per cent silica and is uniform throughout. The sand is angular and hard, and the gravel is practically all quartz.

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PROSPECTING AND EXPLORATION

The first explorations were by means of test pits dug by hand. These proved of little value as they could only be sunk to a limited depth. A contract was then made for drilling test holes over that portion of the deposit which it was desired to explore. These test holes were put down by hand at a contract price of $1.50 per foot and spaced approximately 100 feet apart in each direction.

At present the method of prospecting is to dig test holes with a small Hayward clam-shell bucket worked by hand. The bucket digs a hole about 12 inches in diameter and is used above the water line inside a steel-pipe casing. Below the water line a 4-inch pipe is sunk as a casing within which a drill tool is operated. This tool is made from a piece of 3-inch pipe about 4 feet long with one end filed off to a rough cutting edge. A few inches above this edge a flap valve is placed opening upward. The tool is suspended from a light tripod by a half-inch rope running through a pulley and is operated by hand. Three men are used in this work and average about 50 feet of drilling per day at a cost of 30 cents per linear foot.

CHOICE OF METHOD

Originally the desired product was concrete gravel and coarse sand which occurred in the best quantities in the Lowland deposit. The overburden being of no value whatever, had to be disposed of as quickly and economically as possible, so it was cast into the pond formed by previous workings.

In order to use the equipment taken over in the purchase of the property, consisting of a Browning locomotive crane and an "A" frame derrick, both equipped with 1-yard buckets, a screening plant was constructed close to the railroad track and dry plant. The material was dug by the crane and derrick, loaded in 4-cubic yard side-dump cars and hauled by a steam locomotive to the screening plant.

The cars were dumped into a hopper and the material raised by a continuous bucket elevator to a jacket screen which separated the sand from the gravel. The gravel was loaded by gravity either into cars or a storage bin, and the sand was discharged into a wash box which separated it into coarse and fine sand. The coarse sand was for use as blast sand and the fine sand was wasted.

The disposal of this fine sand eventually became an acute problem so some change was necessary. Then too, by this time, a change in the market was evident. An increased demand for a properly prepared concrete sand was evident, as well as a demand for a fine sand that could be used for plastering and brick mortar. In order to meet this demand it was decided to entirely revamp the plant.

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Due to the shallowness of the deposit and because it contained no boulders or large stones, it was decided that a pump dredge would handle the material cheaper than any other device. In order to avoid pumping long distances, an inexpensive screening plant was built which could be replaced by another plant in a new location when the pumping distance became too great. As steam power only was available, the dredge was constructed to accommodate boilers and an engine, and as there was no way of getting a dredge hull to the property it had to be built at the site.

In 1926 electric power became available and since the boiler equipment was reaching a state where renewals were necessary it was decided to equip the plant throughout with electric machinery. This change was made during 1926 and the electric machinery has proven more efficient and less expensive to operate than the steam-operated equipment.

During all this time the market was broadening and a demand was appearing for a greater variety of grades in both sand and gravel.

The demands were met and in some cases anticipated by the construction of new plants for special purposes, until at present four plants are in operation consisting of a wet-screening plant for the preparation of concrete gravel, concrete sand and fine or plastering sand; a dry plant for the production of blast sand; a re-screening plant for the preparation of filter gravel; and an hydraulic-classifier plant for the preparation of special sands for such purposes as molding, core, filter, and slate-rubbing sand.

This last plant was built to utilize the fine sand which had been discarded as waste during previous operations. The flow sheets of the various plants are shown in figures 1, 2, 3, and 4.

DREDGE

When originally built, the dredge hull had to accommodate a Corliss engine and boilers so that it is somewhat larger than is necessary at present. The hull is 30 by 70 by 5 feet deep and is built throughout of long-leaf yellow pine. The deck and sides are of 3-inch planks and the bottom planks are 4 inches thick. A deck house of galvanized iron covers all equipment. The details of this hull are shown on the accompanying plan (fig. 5).

The equipment consists of a 12-inch Morris Machine Co. sand pump with Taylor-Wharton manganese-steel removable liner, side plates, and impeller. The pump is driven by a direct-connected 300-hp. General Electric synchronous motor using 400-volt, 3-phase, 60-cycle, current. Synchronous motors were selected on account of low initial cost and a power factor affording a 5 per cent reduction of current consumption.

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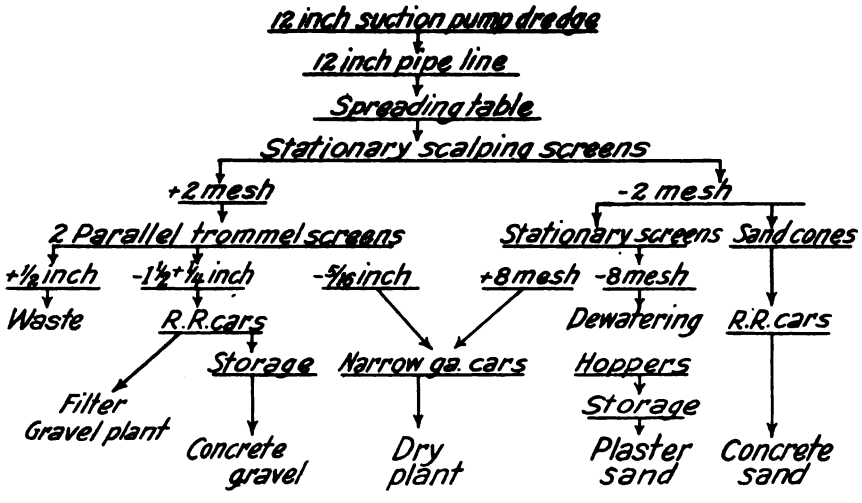

Figure 1.-Flow sheet of sand and gravel or wet plant

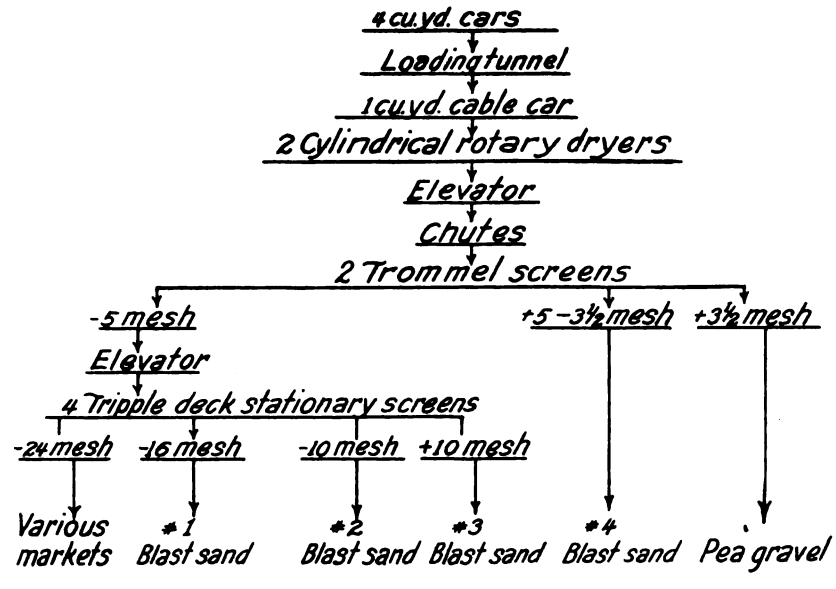

Figure 2.-Flow sheet of blast-sand or dry plant

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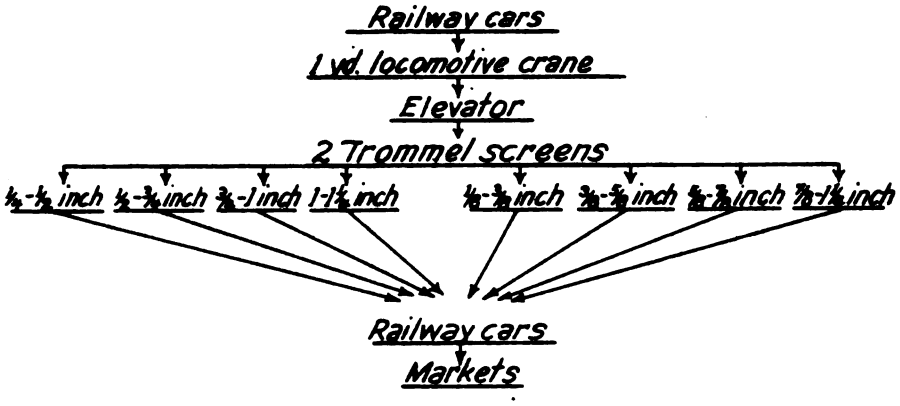

Figure 3.- Flow sheet of filter-gravel plant

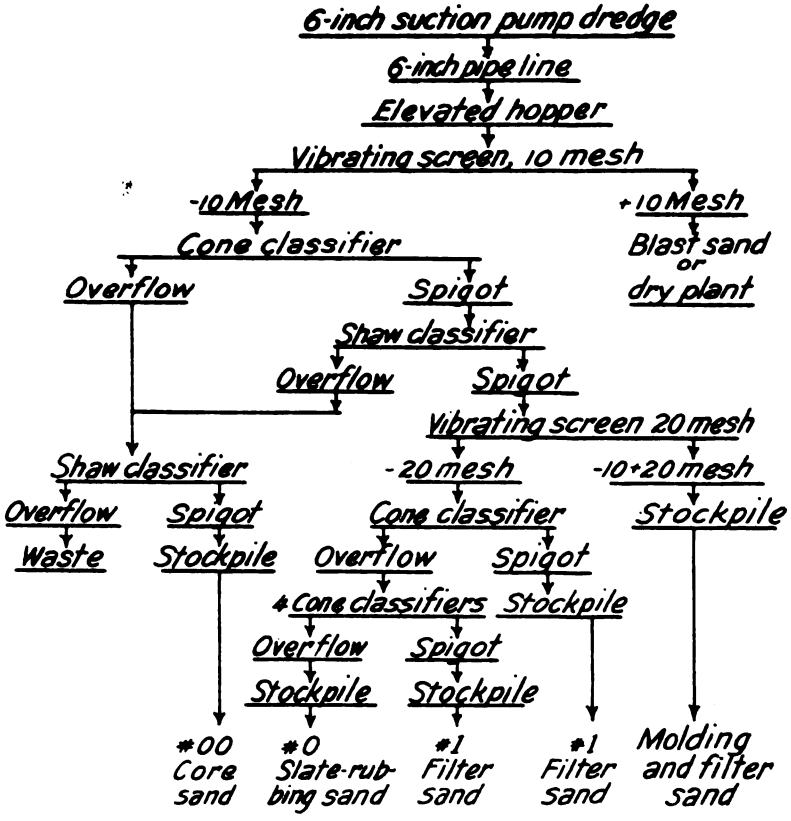

Figure 4.- Flow sheet of classifier plant

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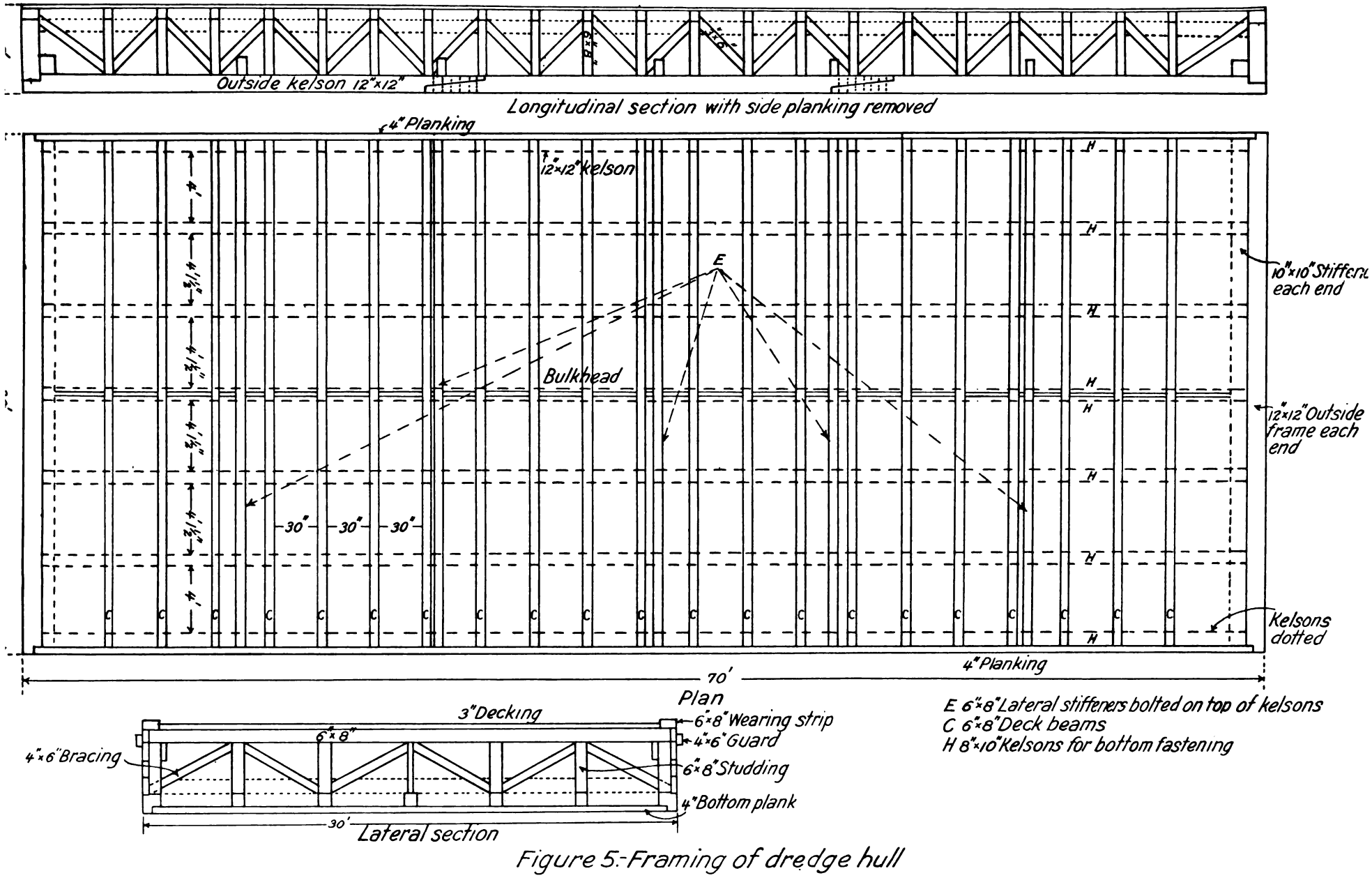

Figure 5.-Framing of dredge hull

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To eliminate starting troubles the motor is equipped with an automatic starter and push-button control so that to stop or start the pump all the operator has to do is to push the button.

For priming there is a 1½ inch Nash vacuum pump driven by a 2-hp. motor and there is also a 2-inch D.S.V.M. pump driven by a 7½-hp. motor which provides a water seal to keep sand out of the main bearing.

The suction line is suspended from an "A" frame by wire cables and is raised and lowered by a hoisting engine driven by a 20-hp. induction motor.

Current for these small motors and for lighting the boat is furnished from a bank of three 10 kv.a. transformers which reduce the 4,000 volts to 220 volts for the motors and 110 volts for the lighting circuit.

The dredge is moored to convenient points on the shore by wire cables which are operated by hand winches.

PIPE LINE

Various types of pipe have been used in the discharge lines, but the most satisfactory has been pipe made by the American Rolling Mills Co. of a special analysis steel with welded seams. This pipe is carried over the water on pontoons each 8 by 4 by 2½ feet. For convenience in handling, the pipe line is generally made up with rubber sleeves about every 40 feet. The pipe line is 12 inches in diameter throughout and at the screening plant is carried up a long incline to a point of discharge 32 feet above the loading track.

SCREENING PLANT

The pipe line discharges on the narrow end of a fan-shaped spreading table which slopes 7/8 inch in 1 foot toward the stationary screens. This table is 20 feet wide at the lower end and spreads the material in a thin layer. The material flows from this table onto a woven wire screen 20 feet long and 4 feet wide. This screen is set at an inclination of about 45° and so located that the discharge from the table hits the top of the screen.

As there is practically no material over 2 inches in size the screen used is 2 meshes to the inch of 0.162-inch wire, giving a clear opening of 0.338 inch. The purpose of this screen is to separate the gravel from the sand; the gravel is discharged into a chute which conveys it to 2 parallel revolving screens each 16 feet long and 36 inches in diameter and equipped with sand jackets 12 feet long. The purpose of these screens is to remove small roots or trash from the gravel and also to screen out any sand not removed by the stationary screen. The inner section of the screen is punched metal with holes 1½ inches in diameter, while the sand jacket is punched with holes 5/16 inch in diameter.

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The material passing the inner screen and retained on the sand jacket is therefore gravel from 5/16 to 1½ inches in diameter and is chuted directly into cars, there being no gravel bins at the plant. The sand passing through the jackets enters a hopper from which it is loaded by gravity into small cars which convey it to the dry plant over a narrow-gage track.

The sand passing the 2-mesh stationary screen is carried into a series of sand cones of the Dull type which dewater the sand and also remove any excess of fines which may be present. These cones discharge the dewatered sand directly into cars for shipment as concrete sand. When fine sand for plastering is desired another screen similar to the 2-mesh screen but with 8-mesh openings is placed directly ahead of the 2-mesh screen. This screen separates the sand into fine and coarse sand. The coarse sand rejected by this 8-mesh screen enters a hopper and is loaded by gravity into narrow-gage cars which take it to the dry plant. The fine sand passing the 8-mesh screen goes to the dewatering hoppers and is loaded into cars for shipment as plaster sand.

To facilitate handling these screens they are made in three sections, each 6 feet 8 inches long on wooden frames.

DRY PLANT

The dry plant is operated to produce blast sand and filter sand which are shipped in box cars. The raw material used is the coarse sand produced at the wet plant, which is loaded at the wet plant in 4-cubic-yard cars on a 3-foot gage track and hauled by gasoline locomotive to an elevated trestle and dumped on a storage pile. This storage pile covers a concrete tunnel in which there is a 24-inch gage track carrying two 1-cubic-yard Kopple side-dump cars.

The sand is loaded into these cars through gates in the roof of the tunnel and the cars are then hauled up an inclined trestle by cable to the receiving hopper of the dryers.

There are two rotary-type direct-heat dryers, each with a rated capacity of 20 tons per hour, and using low-volatile coal for supplying heat, the consumption of fuel being about 1½ tons per day in each dryer. The dryers are belt driven by a 50-hp. synchronous motor.

The wet sand is dumped from the Kopple cars into feed hoppers located over the dryer furnaces and is fed through a gate into the receiving end of the dryers. The dryers make 15 r.p.m. and discharge the dry sand into a hopper. From this hopper the sand is picked up by a bucket elevator, raised 35 feet, and discharged into two parallel revolving screens, each 12 feet long and 36 inches in diameter. Each screen is in 2 sections, the first of which is equipped with wire cloth having 5 meshes to the inch and the second with wire cloth having 3½ meshes to the inch.

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The material passing the 5-mesh screen drops into a small hopper and is raised about 10 feet by a bucket elevator for further screening.

The material retained on the 3½-mesh screen is oversize and is discharged into a loading bin for market as pea gravel. The material passing the 3½-mesh screen also goes to a storage bin as No. 4 blast sand.

The sand which has passed the 5-mesh screen after being raised by the bucket elevator is discharged into chutes which open onto 4 parallel stationary screens. These 4 screens are alike and have triple decks 18 inches wide but varying in length. The upper deck, 20 feet long, is of 10-mesh wire cloth. Material retained on this screen is No. 3 blast sand and is chuted to a storage bin. The second deck of the screen is about 30 feet long and is of 16-mesh cloth. The material from this screen is also chuted to its bin ready for loading as #2 blast sand. The third deck of the screen is of 24-mesh cloth and the material retained on this screen is the smallest size or #1 blast sand. It also is discharged into a storage bin. All of these bins are inside the building so that the sand is kept dry.

The sand which passes through the last screen is too fine for blast sand, but is chuted into an inclosed bin and is sold as a special product for use in several different industries.

The gravity screens are assembled in sections, each 10 feet long and mounted on light wooden frames so that the replacements are easily made. The screens have an inclination of about 45°, so that the material flows over them slowly.

Six men are employed in this plant; a foreman who is also the locomotive crane operator, an engineer in charge of the motor room and who operates the hoisting engine that pulls the cars of raw material from the tunnel; a laborer who loads and discharges tunnel cars; a laborer who feeds the dryers and also attends the furnaces; a laborer in the screening plant and a laborer as helper on the crane. In loading cars the material is chuted into the hopper of a Pratt box-car loader and placed in the car; the loading is completed by the machine.

CLASSIFIER PLANT

During many years of operation a large amount of fine sand accumulated, which was looked upon as a waste product.

Chemical and physical analysis showed that this sand if properly graded could be made to meet the requirements of various industries.

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As this sand was very fine, and of course wet, it seemed impossible to devise a screening method that would give satisfactory results. It was decided to attempt to get the required results by hydraulic classification. A plant was designed by and erected under the supervision of Mr. Edmund Shaw, using Shaw classifiers and cones. With a few minor changes and the addition of two Tyler vibrating screens this plant (see fig. 6) has proved entirely successful.

The flow sheet may appear somewhat complicated, but the plant has been able to produce several grades of sand that have found a ready market which is still being extended.

The classifier plant was erected 50 feet from the railroad track so that material produced could be stock-piled and loaded in cars by a crane as required. The raw material for this plant is the waste sand discharged into the old worked-out portion of the deposit. As the material is fine it can be readily pumped, and a 6-inch pump was selected for this purpose and mounted on a steel hull built at a local shop. The pump is belt driven by a 100-hp. synchronous motor and delivers the material through a 6-inch discharge line to a conical hopper at the top of the plant, 50 feet above the track elevation.

As the proper operation of this plant requires regular feed the discharge from the hopper is through a gate, the opening of which can be easily regulated. The hopper discharge is fed to a 10-mesh Tyler vibrating screen. All material retained on this screen is chuted to a stock pile and treated in the dry plant. The material passing the 10-mesh screen enters a cone classifier for preliminary classification (fig. 7). The spigot discharge from this cone enters a Shaw hindered-settling classifier (fig. 8) and is divided into two components. The overflow from this classifier unites with the overflow from the first cone classifier and all this material enters a second Shaw hindered-settling classifier. The spigot discharge from this second classifier is very fine sand and is stock-piled ready for loading as core or foundry sand. The overflow of this classifier is waste.

The spigot discharge from the first classifier falls on a Tyler 20-mesh vibrating screen. Material retained on this screen is therefore minus 10 plus 20 mesh and is stock-piled and used as filter and molding sand.

Material passing the 20-mesh screen flows into a third Shaw classifier, producing a spigot product of minus 20 plus 35 mesh, which is sold as filter sand.

The overflow from this classifier passes through 4 Deister-cone baffle-classifiers arranged in series. These reclaim any filter sand carried over in the overflow of the third Shaw classifier. The spigot discharge of these classifiers is therefore filter sand, while the overflow is a somewhat finer sand which is used in slate cutting and rubbing as well as for foundry work.

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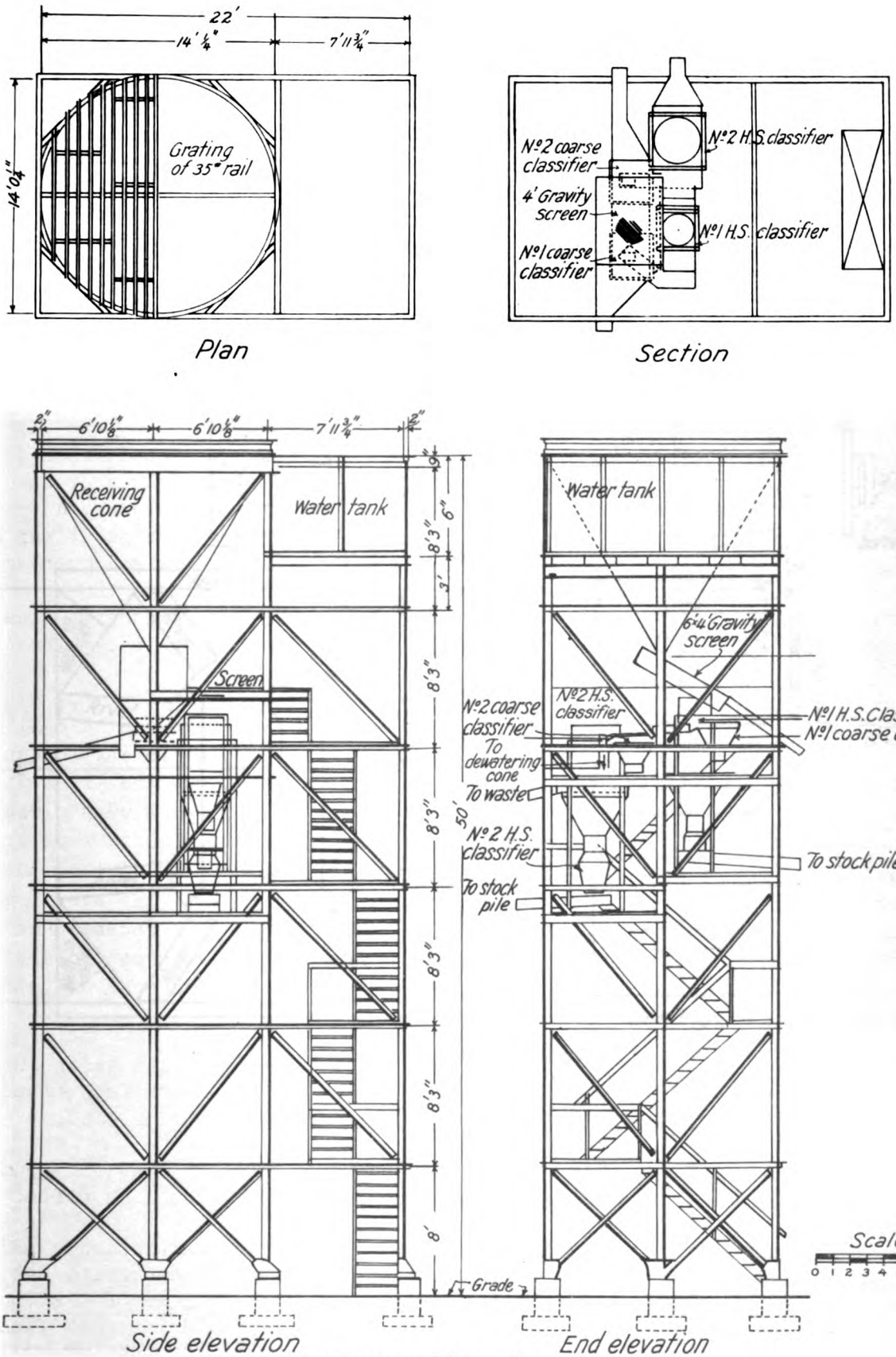

Figure 6.- Classifier plant

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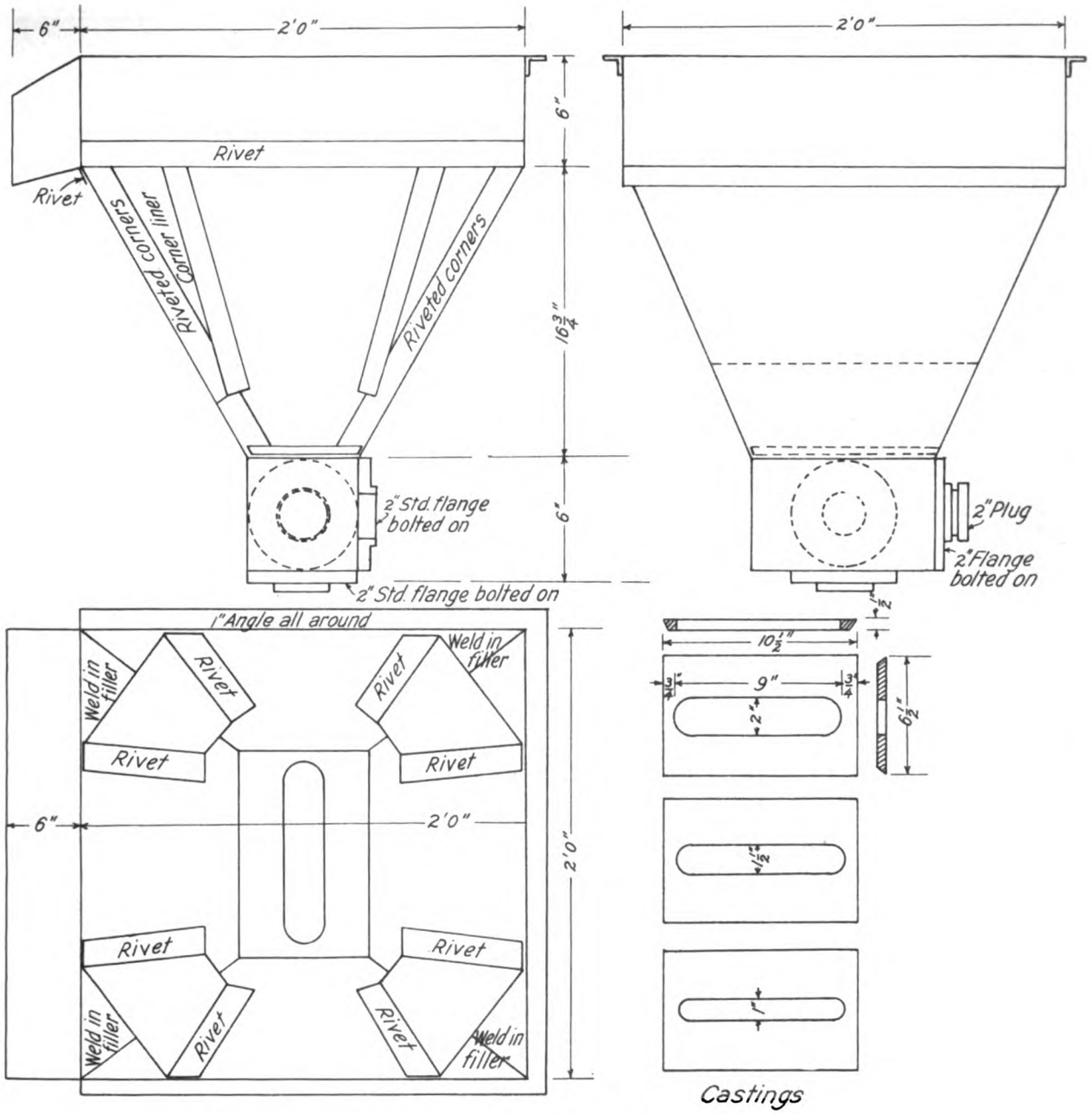

Figure 7.-Coarse classifier

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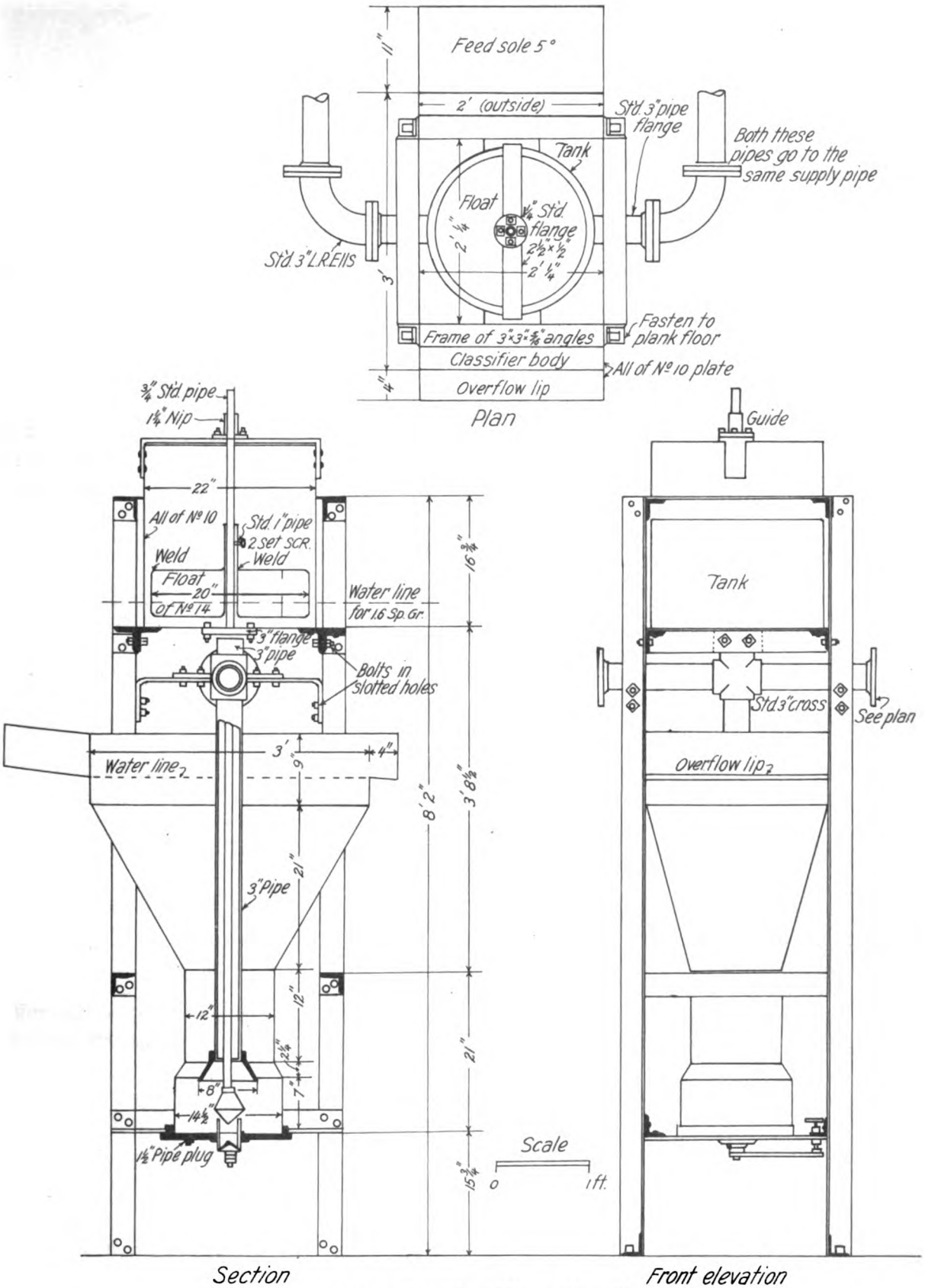

Figure 8.-Hindered-settling classifier

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FILTER-GRAVEL PLANT

In order to produce the various sizes of gravel demanded for filters, a small gravel rescreening plant was built. This plant consists of two parallel revolving screens so constructed that the punched metal plates can be easily changed to accommodate the requirements as to size of gravel. The plant is 30 feet high, the gravel being raised by bucket elevator to the screens, discharged by gravity to ground storage and loaded into cars by a locomotive crane.

Water required in both the classifier and filter-gravel plants is supplied by a 6-inch centrifugal pump driven by a 20-hp. General Electric motor and in order to secure a constant head in the classifier plant a tank is provided at the top of the plant to which the water is pumped. Each classifier receives water by separate pipe line from this tank.

WAGE SCALE

		Per month
Foreman	2	$200.00
Watchman	1	125.00
		Per hour
Engineer	1	$ 0.675
Mechanic	1	.60
Pump Runner	1	.60
Crane operators	2	.55
Pump Runner	1	.55
Engineer	1	.55
Mechanic	1	.55
Loco. Engrs.	2	.50
Laborers	5	.45
Laborers	6 - 12	.40

Normally the working day consists of 9½ hours, five days per week, with 5½ hours on Saturdays, work being carried on continuously throughout the year.

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SUMMARY OF COSTS

Period covered: 1927

Tons, sand and gravel produced 210,000

	Labor	Super-intendence	Power	Fuel	Other supplies	Total
Operating costs						
Stripping by A - Frame derrick, casting overburden into pond	$0.008	$0.002		$0.001	$0.001	$0.012
Pumping and conveying	.031	.010	$0.074		.016	.131
Wet screening and loading	.089	.020	.003		.037	.149
Storage	.005			.003	.002	.010
Repairs and maintenance	.023				.004	.027
Miscellaneous expense	.013				.004	.017
Total operating cost of producing wet sand	.169	.032	.077	.004	.064	.346
Overhead						
Depreciation						.08
Depletion						.013
Taxes						.01
Insurance						.017
Selling						.04
Miscellaneous overhead						.01
Total overhead						.17
Total costs per ton						.516

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DRY PLANT

SUMMARY OF COSTS

Period covered: 1927

Tons produced - 15,500

Operating costs per ton of dry sand

	Labor	Super-intendence	Power	Fuel	Other supplies	Total
Hauling	$0.037	$0.005			$0.062	$0.104
Drying	.226	.034	$0.130	$0.160	.112	.662
Screening	.158	.026			.054	.238
Loading	.057	.005	.010	.035	.027	.134
Miscellaneous plant ..	.020			.036		.056
Total operating cost dry plant	0.498	.070	.140	.231	.255	1.194
Operating cost of producing wet sand	.169	.032	.077	.004	.064	.346
Total operating cost..	.667	.102	.217	.235	.319	1.540

Summary of costs in units of labor, power and supplies during an average month

Labor (man-hours per ton)

Stripping	0.0215
Pumping	.06
Screening	.10
Loading	.05
Track repairs	.02
Drying	.10
Supervision	.036
General	.06

Percentage of Total Cost - 59

Power and supplies

Power, kw.h. per ton

Pumping	2.04
Wet screening	.163
Drying	3.43

Cost of other supplies in percentage of total cost - 21

Power and supplies, percentage of total cost - 41.

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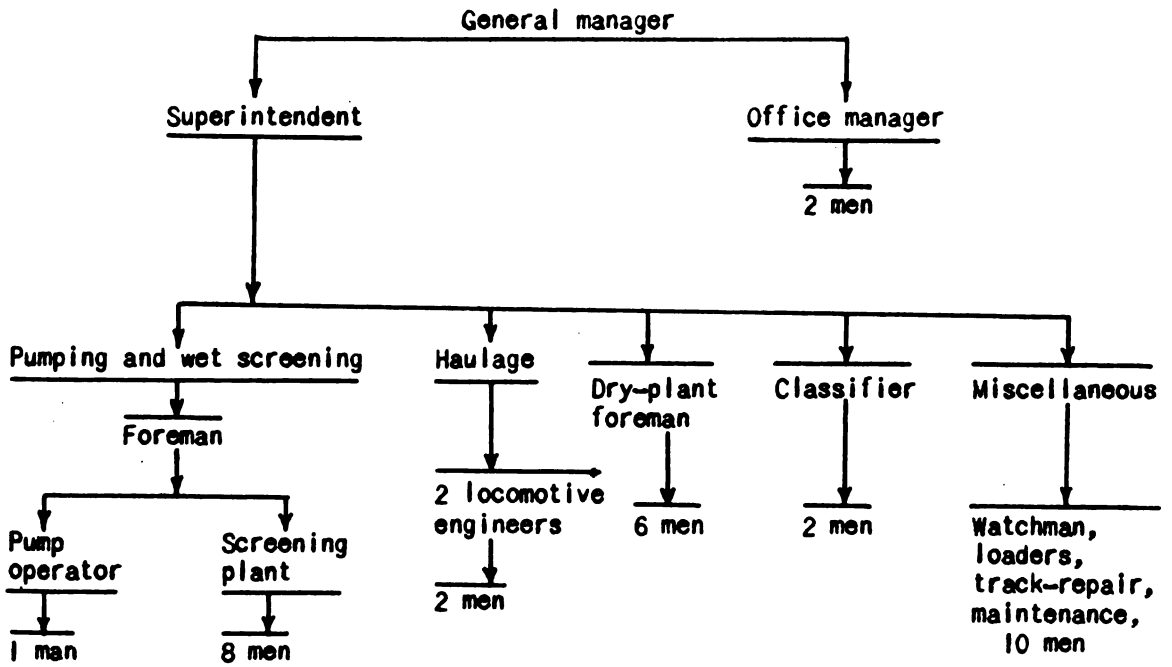
ADMINISTRATIVE ORGANIZATION



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